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## *HUMAN NUTRITION AND INDIVIDUAL VARIABILITY*

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# NUTRITION RESEARCH

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# *HUMAN NUTRITION AND INDIVIDUAL VARIABILITY*

By ROGER J. WILLIAMS*

As a safe first approximation, let us assume that human identical twins have identical nutritional requirements. This statement implies that other individuals who are genetically different have distinctive needs — an idea exactly in line with modern genetic knowledge. We know that the various enzyme efficiencies of organisms which govern the details of their metabolism are determined by the distinctive genes, the carriers of inheritance.

If this implication is accepted, we come to the really important question: *To what extent* do the nutritional needs of human individuals differ? — a question which has received very little attention. Practically every worker in nutrition is aware of variation. Many have *assumed* that it is small, but the search for definitive information has been neglected.

To illustrate the importance of this question, let us suppose that the nutritional need for pantothenic acid for optimal health varies from individual to individual in a typical human population over about a 20 per cent range, from 9 to 11 mg. per day. A scatter diagram of individual needs will presumably yield a bell-shaped curve with a peak at 10 mg., the supposed average need per day. Let us suppose, on the other hand, that the needs vary in a typical population from 4 mg. to 20 mg. per day, a 5-fold range. Again we can construct a scatter diagram (if we have the data) with a distribution curve which may again have its peak at about 10 mg. per day. In each of the two supposed cases, we may conclude that the human need is for 10 mg. per day. But the practicalities of the situation are very different in this and other cases, depending on whether the range is about 20% or of the order of 5-fold (or more).

In the case of pantothenic acid we know little about individual needs. Despite its availability for 15 years, the human need for it has been directly demonstrated only in recent years (1). If the range in human needs is large, then the statement that widespread presence of pantothenic acid in foods insures against deficiency is indefensible; it is conceivable that some individuals because of high needs have great difficulty in getting an optimal amount. Widespread distribution is no guarantee against deficiency. Pantothenic acid is no more widely distributed than thiamin, for instance, which also appears

*From the Clayton Foundation for Research and the Biochemical Institute and Department of Chemistry, The University of Texas, Austin, Texas.

to be present in every living thing and yet may be distributed in diets in suboptimal amounts. The fact that pantothenic acid is quantitatively more abundant than thiamin has nothing to do with the question, because pantothenic acid needs are also relatively much higher than thiamin needs.

The importance of having definitive knowledge about variability is tied up with this fact: The value of nutritional knowledge does not depend on its efficacy in groups of inbred experimental animals, but rather upon its efficacy in heterogeneous populations of poultry, farm animals, pets, and finally human beings themselves. Our interest in human nutrition, furthermore, cannot be said to be restricted to 80, 90, or even 95 per cent of the population. Indeed we may be more interested in those who have unusual demands than in those who are average in this respect. Those who have no nutritional or health problems — if there are such — require no attention.

It will be quite impossible here to discuss each nutrient for which there is evidence — direct or indirect — of individuality in needs. Among the nutrients which have been studied more extensively, we shall hope to find those which will serve as prototypes of other nutrients about which we have relatively little information.

### *Calcium*

From the standpoint of calcium's place in nutrition and the probability that diets may be lacking in it, it is almost unique, and the amount of study that has been devoted to it is enormous. An early observation relating to variation in human calcium needs was made by Macy (2); she cites two normal 5-year-old children who, in the same environment and eating the same food, retained 264 mg. and 469 mg. of calcium, respectively, per day for 45 days. A more recent study (3) dealing specifically with variation indicates that the variance cited above underestimates that which occurs among human male adults. Balance studies were performed on 19 healthy males, each receiving initially 229 mg. of calcium daily. On this regimen one individual was in calcium balance while another was losing calcium at the rate of 256 mg. per day. The requirements for calcium balance in the 19 individuals, in experiments of at least 20 days' duration, varied from 222 mg. to 1018 mg. On the basis of the calcium requirement per kg. of body weight the range was 3.52 to 16.16 mg. On either basis the range is nearly 5-fold.

On the basis of this and many other studies the Food and Nutrition Board of the National Research Council state (4) with respect to calcium that "wide variations among individuals prevail, suggesting metabolic differences not explained by intake or absorption." It seems safe to conclude that if a

large population of individuals (both male and female) were studied the range in calcium needs would be found substantially larger than 5-fold.

It is well recognized that in Oriental countries millions of people never get calcium at levels such as are regarded adequate in America. It is commonly supposed that the Oriental people have become adapted to a lower calcium intake. The mechanism involved in this supposed adapation is unknown, and it is not known to what extent this relatively low calcium intake may modify growth rates or ultimate stature.

If individuals who have a high calcium requirement are placed in an environment where they cannot get the desirable amount, they will either exist in a deficient and unhealthy state or will be eliminated from the population. It seems probable that in Oriental countries where food calcium is scarce, there has been genetic selection, and that through the centuries those with high calcium demands have been eliminated from the population. It seems likely, in the absence of evidence to the contrary, that different ethnic groups have genetically different requirements for calcium and that the Oriental adaptation is at least partially genetic.

In animal experiments in our laboratory (5) designed particularly to study the question of variability in individual needs, the results indicated that even individual experimental mice from an inbred colony have substantial variance in their calcium needs. The same is true of rats (6) and there is evidence that substantial variance in calcium need exists among cattle (7). For example, some cattle in a herd suffer from calcium deficiency when they are placed on wheat pasturage, while others show no symptoms of "wheat disease." Critical nutritional experiments on calcium needs involving animals having as heterogeneous an ancestry as human beings are unknown to the writer. It seems highly probable that such experiments would yield results at least as divergent as those of Steggerda and Mitchell (3) cited above.

### *Vitamin A*

Since the nutritional importance of vitamin A has been recognized for over 40 years and its chemical nature for over 20 years, it is a nutrient for which we might hope to get data on variability.

In animal assays of vitamin A, high variability in response is continually observed. For this reason rats used for this purpose must be selectively bred, and as many as 10-15 animals used in each test.

Paul and Paul (8) studied the effects of various levels of vitamin A particularly on the eye and tooth development of a group of 19 albino rats.

They obtained results which may be tabulated as follows:

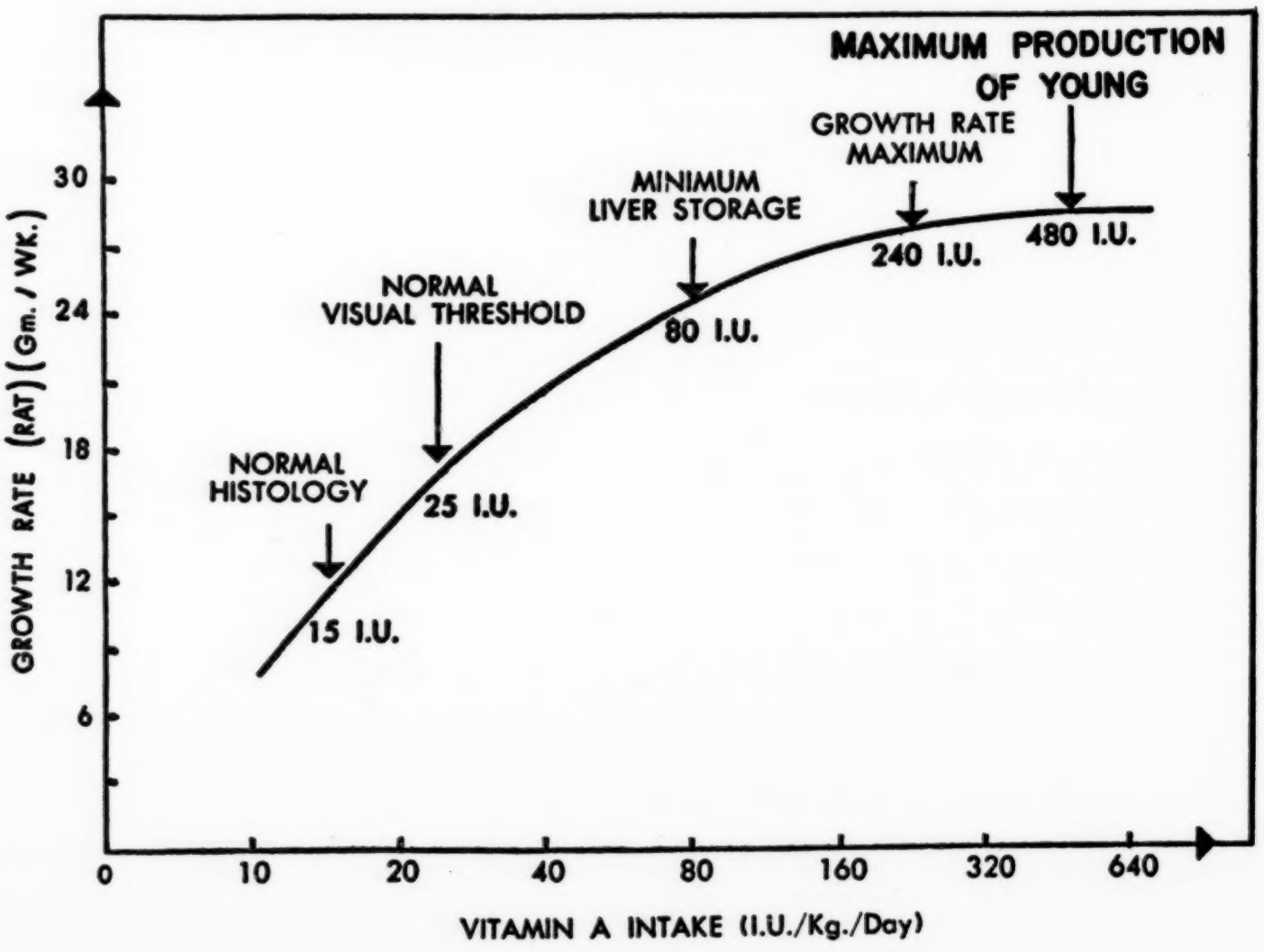
| Level of intake | Per cent normal with respect to eyes | Per cent normal with respect to teeth |
|---|---|---|
| 2 units per 100 g. body weight ..... | 26 | 0 |
| 4 units ..... | 60 | 20 |
| 20 units ..... | 95 | 95 |

It is apparent that 4 units was enough (on the basis of the criteria used) for four of the rats, but that 20 units was *not* enough for one. Thus we have evidence of more than a 5-fold variation even among a small relatively homogeneous population of laboratory rats. It is possible, of course, that the one rat was aberrant for reasons unrelated to vitamin A need, but this seems unlikely in view of other evidence with regard to variability in the vitamin A needs of rats.

Bessey (9) has depicted in the following graph the effects of different levels of vitamin A intake on experimental rats. It may be noted that maxi-

THE NATURE OF NUTRITION (Bessey)

(Illustrated with data from vitamin A studies)



mum production of young is attained only when the vitamin A level is 48 units per 100 g. of body weight. These data suggest the probability of a 10-fold variation in vitamin A needs of rats, though actually the specific question of how variable individual animals are in their needs has never been squarely faced.

Over twenty years ago (1932) Mead Johnson & Company offered a $15,000 award for information which would establish the vitamin A level required by human beings. Thirteen years later the award was withdrawn because no investigation had been completed or was in progress which would answer the question.

Probably high variability in human needs is a basic difficulty. On the basis of rat investigations, this variability would be expected to be 10-fold or possibly more. Cases have been reported to the writer directly (10) and indirectly (11, 12) of individuals who seemed to require for continued good health 50,000-100,000 units per day. This is 10-20 times the approximate daily allowance figure (5,000 units) set by the Food and Nutrition Board years ago — an allowance which itself was intended to be generous rather than the opposite. If, as seems likely, some individuals need not more than 2,000 units per day, the range of human needs is enormous.

In line with the idea that human vitamin A needs vary greatly from individual to individual are the findings of Popper and Steigmann (13). They studied the vitamin A plasma levels and carotenoid plasma levels in 65 hospital controls (fracture cases, etc.). Among these, they found a 10-fold inter-individual range in vitamin A levels and a 30-fold inter-individual range in carotenoid levels. When repeated vitamin A determinations were made on plasma samples from the same individuals for 7-18 days, the values were "without any considerable changes."

### *Vitamin D*

Because of its connection with the long-recognized childhood disease, rickets, the human needs for this vitamin have been studied particularly in children; virtually nothing is known about adult needs.

Among normal children there is evidence of variability of vitamin D needs. According to Spies and Butt (14): "The activated milk does not exhibit sufficient potency in vitamin D for the prevention of rickets in cases in which a *susceptibility exists*" (italics added). They indicate that these children may require 5,000 to 10,000 units daily, and that an occasional child may require 60,000 units per day. The figure 10,000 units is ten times the "allowance" set by the Food and Nutrition Board. Even more convincing

evidence of highly variable needs is the existence of well-authenticated cases of "Vitamin D resistant rickets" which respond to vitamin D therapy but only when enormous doses, sometimes up to 100,000, 500,000, or even 1,500,000 units, are administered (15, 16).

It may be well to point out in this connection that the magnified need for vitamin D in the case of specific children is real and within our purview, regardless of whether the children have difficulty in absorption, transport, or utilization, or for some other reason require extraordinarily large amounts. Variability in needs, regardless of the basis of the variability, is the subject of our discussion and is worthy of attention.

## *Vitamin C*

In young growing guinea pigs the amount of ascorbic acid required to prevent scurvy symptoms is about 0.5 mg. per day. There are, however, distinct gains in health when the intakes are up to 10 times this amount (17). While data with respect to individual guinea pigs are not available, common observation suggests that the needs of individual animals vary substantially. In these animals scurvy symptoms do not appear until the tissue saturation has reached the low level of 20 per cent. Even at 40 per cent tissue saturation, however, defects in incisor development appear. It is not known what level of saturation is optimal for guinea pigs, but in view of the increased health resulting from ten times the minimal amount needed for protection against scurvy, it would appear that the optimal level of saturation is high (18).

The serum ascorbic acid levels in a group of 33 school children were found to vary widely from 0.02 to 3.1 mg. per cent; while these children were in a group judged to have some vitamin deficiency, the group constituted approximately 50 per cent of the school population examined (19). The amount of ascorbic acid intake required for producing tissue saturation was found to vary from 0.6 mg. to 2.85 mg. daily per kg. of body weight even when as few as nine individuals were studied (20). A survey of the general population would probably reveal substantially more than a 5-fold range in the amounts of ascorbic acid required to bring about saturation, and this suggests that the range in needs is at least this large, assuming for example that some set fraction of 100 per cent saturation is optimal for all individuals. Due to the variation in the vulnerability of different tissues, however, it is probable that some individuals require for health a higher degree of saturation than others, and it may be that these are individuals whose tissues are difficult to saturate. The enormous spread in the serum ascorbic acid levels of the school children (155-fold) suggests that variation in needs is large. Dalldorf

(21) hints at the existence of something parallel to vitamin D-resistant rickets when he states: "Even these large amounts [75-150 mg. per day for adults, including women during pregnancy or lactation], however, are inadequate to maintain saturation *in certain patients*" (italics added). He points out that in Hodgkin's disease, protracted fever from various causes, active rheumatic heart disease, and tuberculosis, the ascorbic acid requirement may be "extremely high."

Unless one has a strong bias in favor of uniformity, he is likely to conclude from the diverse evidence that the requirement of human beings for ascorbic acid probably varies over something like a 5-fold range.

### *Thiamin*

Pertinent to the problem of individual human variation in thiamin needs are the findings of Light and Cracas (22) that different strains of white rats showed marked differences in their thiamin needs as judged by growth responses. One strain grew somewhat better on 2 μg. per day than did another strain on 4 μg. per day. Undoubtedly inter-individual differences existed within each strain (not closely inbred), and it would appear certain that among rats of heterogeneous ancestry the variation in needs is substantial. Different breeds of chickens appear to have different levels of thiamin needs also (23) and the inter-individual variation among chickens of heterogeneous ancestry would be expected to be several-fold.

Most of the investigations of human thiamin needs have been made on the assumption that normal man has a requirement at the adult level which covers a relatively narrow range. If this is the case, then the establishment of the need for a few individuals (who may yield reasonably concordant values) would be sufficient to establish this normal.

Najjar and Holt (24) presented an example of an extensive and almost heroic study of thiamin needs on nine young males 16-23 years of age. These individuals consumed a "synthetic" basal diet (with vitamin-free casein as the protein) similar to those used in animal experiments. One milligram per day of thiamin was the starting level, and it was planned that the amount should be reduced gradually until deficiency symptoms should appear. Even when the levels were reduced to about 0.1 to 0.2 mg. per day, the individuals remained symptomless, and thiamin was therefore eliminated from the diets altogether. In the course of the next 3-5 weeks, 4 out of the 9 developed clinical thiamin deficiency, one was borderline, and the others showed no clinical signs of deficiency, even during 7 weeks of observation. Subsequent study showed that the individuals who remained symptomless had on the

average 20 times as much free thiamin in the feces as did those who showed symptoms, and this finding pointed strongly to the synthesis of thiamin by intestinal organisms.

If we take these results at their face value, we come up with the conclusion that some individuals (for some periods and on certain diets) may require substantially no ingested thiamin. The basic reason would seem to lie in their ability to harbor an intestinal flora capable of furnishing this need. The diminished nutritional need is just as real, however, as if it had some other basic cause.

There is not room here to discuss this and other human experiments in detail. An average adult human body contains an amout of thiamin of the order of 70 mg. (25). In deficiency states excretion may be very low (a few $\mu$g. per day), and depletion is correspondingly slow. Furthermore, there is good reason to believe that thiamin deficiency actually exists in individuals long before clinical symptoms appear. These facts make clinical experiments difficult to interpret. Adult animals are difficult to deplete to a degree such that they show overt signs of thiamin deficiency, but his does not necessarily mean that they can be kept in optimal health at low levels of intake.

One recent study has involved attempting to explore thiamin needs on the basis of excretion (26). For six out of eight normal women 500 $\mu$g. thiamin per 1,000 Cal. was judged adequate. For six out of eight, the 300 $\mu$g. level was judged inadequate, and for two it was borderline. There were often about 3-fold spreads in the amount of thiamin excreted by different individuals on the same level of intake.

In line with the idea of substantial variability in individual needs is the fact that the thiamin in the blood (mostly in cells) is usually present either at a comparatively low level (4-5 $\mu$g. per 100 ml. — about 30 per cent of cases) or at a level about twice as high (9-10 $\mu$g. per 100 ml. — about 70 per cent of cases) (27).

| Mg. Daily | Number of Individuals |
|---|---|
| 0.40 — 0.59 | 3 |
| 0.60 — 0.79 | 4 |
| 0.80 — 0.99 | 4 |
| 1.00 — 1.19 | 2 |
| 1.20 — 1.39 | 1 |
| 1.40 — 1.59 | 1 |

Pett (28) has arrived on the basis of data, which are admittedly not entirely satisfactory, at the preceding figures for the thiamin requirements of 15 individuals. If these data are accepted as valid, we find even in a small group nearly a 4-fold variation. If we had adequate sampling of a large population the spread might be larger. We may conclude, therefore, on the basis of the sum total of evidence that the inter-individual variation in thiamin needs appears to be at least several-fold.

### *Other B Vitamins*

Miscellaneous evidence of variation in the needs for other B vitamins may be cited.

In a group of only 5 monkeys Tappan (29) *et al.* found one which required only 11 weeks to exhibit niacin deficiency and which appeared to require 30 mg. per week for maintenance. At the other extreme was an animal which required about 39 weeks to exhibit symptoms and appeared to require only 6 mg. per week. In human populations where the food consumption is about the same for all, some individuals contract pellagra while others remain free. That large numbers of cases are not necessary to exhibit variance is shown by a recent experiment of Goldsmith who found that among three patients consuming the same diet for more than 90 days, one showed symptoms of niacin deficiency, one was suggestive of deficiency, and one showed no symptoms.

Recent studies (30) have shown that some babies require 3-4 times as much vitamin $B_6$ as others in order to prevent the excretion of xanthurenic acid after a test dose of tryptophane. These same babies develop clinical vitamin $B_6$ deficiency when the intake is low, while others do not.

The amounts of folic acid required by different patients for the alleviation of their anemia symptoms are highly variable. Some respond to as little as 0.5 mg. per day; others will not respond to 2-3 mg. but will to larger doses. Spies and Butt (31) recommend about 10 mg. per day for the average patient.

That the vitamin $B_{12}$ needs of individuals vary substantially is indicated by the work of Wetzel and co-workers (32) and others (33) showing that supplemental vitamin $B_{12}$ induces a growth response in some, but not all, children. The rates of excretion of vitamin $B_{12}$ vary in different individuals under comparable conditions over at least a 15-fold range (34), suggesting the possibility of a large range in individual needs.

The choline needs of various strains of rats have been investigated with relative thoroughness (35, 36, 37, 38). Among these, there were individual animals for which 2 mg. of choline per day was enough (and perhaps more

than enough), but others for which 10 mg. per day was *not* enough. The indications of at least a 5-fold spread in the needs of individual animals among animals of the same breed suggests that variation would be more than this in a heterogeneous population of animals or of human beings.

### *Amino Acids*

That amino acid needs are distinctive for different individuals is suggested by the fact that individuals exhibit highly distinctive amino acid excretion patterns (39), salivary patterns (40), and duodenal juice patterns (41). There are wide ranges in the amino acid levels of blood, but the distinctiveness of these patterns has apparently not been investigated.

Direct experiments (42) involving a few healthy young men have indicated the following ranges in the amounts required to maintain nitrogen balance: tryptophane, 0.15 to 0.25 g. per day; lysine, 0.4 to 0.8 g.; leucine, 0.5 to 1.10 g.; threonine, 0.3 to 0.5 g. (For a small group of monkeys, the tryptophane requirements varied from about 1.0 to 3.5 g. per week) (29). If large numbers of the population including males and females were tested, it is probable that the ranges would be substantially larger than the above figures suggest.

There is the possibility that certain amino acids, not necessary for maintenance of nitrogen equilibrium in most individuals, may be beneficial for some. Suggestive results in line with this idea are those obtained with glutamic acid (43), glutamine (44, 45, 46), and arginine (47).

### *Potassium and Iodine*

The range in the potassium content of blood serums of entirely well individuals may be as high as from 3.1 to 6.2 meq. (milli-equivalents) per liter (48). Among those who are unwell, the range was found to be from 2.4 to 9.0 meq. per liter (49). These figures suggest the possibility that the potassium needs of individuals may vary substantially. Investigations in the author's laboratory indicate that such levels as those cited above are distinctive for individuals (50).

More convincing evidence of wide variation in potassium needs is the existence of familial periodic paralysis which is accompanied by hypopotassemia. During a paralytic seizure potassium values as low as 1.95 meq. per liter have been reported (51). Relief from the condition results promptly within 30 minutes after the administration of from 2-5 g. of potassium chloride.

It is quite possible that the potassium needs of individuals in general vary substantially, and that those who are afflicted with this disease constitute extreme cases in a continuum. It should be pointed out that variability in needs may be occasioned by increased excretion rates (which may be related to adrenal functioning) or by several other causes, yet the differences in need are real and from the practical standpoint are important regardless of cause. Potassium enters into enzyme systems, and it seems probable that the variation in needs, as exhibited in familial periodic paralysis, may be due to genetically determined differences in enzyme building.

Two lines of evidence indicate that the iodine needs of individuals vary over a wide range. First, in goitrous regions certain individuals show iodine deficiency while others do not, and it has never been shown that the iodine consumption is lower for those who are victims of endemic goiter. Furthermore, in regions near the seacoast where the iodine content of the food is relatively high, some individuals nevertheless exhibit iodine deficiency.

These differences involve variations in need, as indicated by the fact that the spread in the concentrations of protein-bound iodine of the blood in a normal population is large and highly individual. From one study of 402 individuals (52) it was concluded that the range for 99 per cent of the population is from 3.32 to 9.82 $\mu$g. per 100 ml. In another study (53) the range, including patients with pathologies, was from 0 to 4.82 $\mu$g. per cent. In a third study (54), 47 plasma samples yielded values from 1.1 to 28 $\mu$g. per cent. Each individual tends to exhibit relatively constant values, and it seems likely that the iodine needs of individuals vary over a several-fold range.

### *Other Evidence*

From the foregoing it is apparent that substantial evidence for high variability of nutritional needs has accumulated in spite of the fact that very few investigations have been designed specifically to gather this type of information.

This evidence of wide variation, however, does not stand alone, and should be considered against a background of information regarding other variance: anatomical, compositional, enzymic, endocrine, excretory, and pharmacological. Each of these areas, as well as miscellaneous other variances and the genetic basis for all, have been discussed by the writer elsewhere (55), and when this material is considered (some of the data presented are more striking than any relating to nutrition) the case for wide variance in nutritional needs becomes much stronger. The need for more and better data with respect to variations in nutritional needs is urgent.

## *Implications*

It has often been tacitly assumed that the human population is made up largely of individuals who have about average needs — about average, for example, with respect to their needs for calcium, vitamin A, vitamin B, ascorbic acid, thiamin, niacin, vitamin $B_6$, folic acid, vitamin $B_{12}$, choline, tryptophane, lysine, leucine, threonine, potassium, and iodine — and that a minor part of the population is made up of individuals who exhibit values which may be considered abnormal.

This assumption is wholly untenable in the light of the facts of variability and elementary statistical principles. Assuming for the moment that the needs for the particular nutrients we have discussed vary independently of each other, we can readily arrive at the conclusion that there is only one chance in about 66,000 ($2^{16}$) that any individual in a human population will exhibit values within the middle 50 per cent of the range with respect to all sixteen items. This assumption of independence, above, may not be entirely valid (but would be expected to be approximately so), but the principle should be clear; the more items we include (16 is by no means the limit), the less is the chance that any individual will be average with respect to all.

There appears to be no justification whatever for the concept, which is all too prevalent in nutritional thinking, that a representative human being, a prototype of the human species, is one who exhibits no unusually high or unusually low nutritional needs. Such an individual, if he existed, would be a most unusual one and far from typical. The typical individual is more likely one who exhibits some values which are far removed from the average.

If ranges in human nutritional needs were small — ± 20 per cent or even ± 50 per cent — then the discussion which we are engaging in would be valid, but relatively unimportant. Every need could be met, by supplying the average plus a little extra for good measure. But if the ranges are sometimes of the order of 5- to 10-fold, the question we have raised is an acute one.

If humanity could be classed into two clear-cut categories, those with *normal* nutritional needs and those with *abnormal* needs, then our discussion would have to be modified extensively. So far as the writer is aware, there is no evidence as to the existence of such groups, and the burden of proof of their existence can well rest with those who endorse the concept.

## *The Genetotrophic Principle*

It was upon the basis of modern genetic knowledge and the facts of variability that the concept of genetotrophic disease was formulated (56).

The genetotrophic principle is a very broad one encompassing the whole of biology. It may be stated as follows: Each individual organism that has a distinctive genetic background has distinctive nutritional needs which must be met for optimal well-being. This principle is valid whether the variation between individuals of the same species is small or large. If the variation is small, then the principle becomes only of academic interest, since to demonstrate its validity would require hair-splitting experiments and interpretations. If the variation is large, as exemplified by the material presented in this paper, then the genetotrophic principle is of far-reaching significance, because there is no telling how many diseases of obscure origin may ultimately be traced to malnutrition of a type which is based upon an individual's genetically induced specific high nutritional demands. We have elsewhere (57, 58, 59, 60, 61) presented evidence that the distinctive difficulty characteristic of the disease alcoholism — uncontrollable craving for alcohol — is based upon malnutrition of this type. The application of the genetotrpohic principle opens a tremendous field of exploration for medical and dental science. The possibilities in this area hinge to a very large degree upon the *extent of the variation* of human nutritional needs. If the range of variation is small, the importance of the genetotropic principle is negligible. If the range is large, its importance may be beyond measure.

The fundamental concept on which to base our enthusiasm for nutrition and the possibilities of applying the genetotrophic principle is simple. What a fertilized egg cell needs in the way of nutritional elements (and the amounts needed) is determined genetically. If these needs are adequately supplied, the organism thrives; if they are not adequately supplied, the organism sickens. The pattern of needs may be such as to require special attention. If adequate knowledge makes it possible to give special attention and to supply the distinctive needs, the inevitable result should be health instead of disease.

One of the real difficulties in selling nutrition to the public and to those numerous physicians who do not "believe" in vitamins is the fact that there are individuals who seem to pay no attention to nutritional maxims, or to vitamins, minerals, etc., and yet remain healthy to advanced old age. They may even dilute their vitamins, minerals and amino acids continuously with substantial amounts of alcohol. These individuals are very effective living denials of all that the nutritionists have to say, and the public is not slow to see the difference between "theory" and "practice."

When, however, we recognize the high variability which exists, which undoubtedly extends to the self-selection capabilities of individuals, we can

readily understand these phenomenal individuals, who are not so phenomenal actually, since many others approximate them in behavior. Such individuals may have unusually low demands for a number of crucial nutrients (coupled possibly with high demands for items that are abundant in the foods that they like) with the result that they can seemingly violate the laws of nutrition and strongly influence their fellows (consciously or unconsciously) to do likewise.

When the wide variations in nutritional needs are considered, the picture becomes complete. Education based upon the recognition of these variations can proceed without embarrassment or evident denial, and there is hope that the importance of nutrition, for each individual, can become more fully realized.

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